

Final Technical Report for NASA Grant NAG2-1315
Theoretical Studies of Stratospheric and Tropospheric Clouds and Aerosols in Support of
SOLVE
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This project is a collaborative effort with Dr. Margaret Tolbert at the University of Colorado. We proposed a number of theoretical efforts to support NASA's SOLVE Mission which took place in Kiruna, Sweden in the winter of 1999-2000. We proposed to serve as one of the DC-8 project scientists, to work with various instrument teams to better understand the composition of polar stratospheric clouds, and their properties, and to help understand the physical conditions which lead to cloud formation in the polar winter.

In Dec. of 1999, and Jan 2000 Dr. Toon served as the flight scientist for the DC-8 aircraft. These flights were very successful and the data promise to shed new light on the mechanisms of denitrification, the formation of polar stratospheric clouds, the nature of upper tropospheric cirrus clouds, and a number of other interesting issues. During this time Dr Toon, Dr. Mike Mills, and four graduate students were in the field for parts or all of the deployments.

Once these flights were conducted successfully we began a period of data analysis. Dr. Toon and Dr. Tolbert co-chaired an AGU special session at the Spring 2000 AGU meeting in Washington D.C. This meeting concerned the properties of polar stratospheric clouds and their impacts on stratospheric chemistry. We also participated in the Palermo meeting on Solve in 2000. Currently we are working to finish a series of papers on the SOLVE data set. We have drafts of two papers with Y. Kondo concerning the deposition of nitric acid on ice. We find significant amounts of nitric acid are on the ice below 215K, in agreement with new lab data obtained in the Tolbert lab. However, at warmer temperatures little nitric acid seems to be on the ice. We also have two draft papers on the MASP PSC particle data. We find the MASP large particle data correlates very well with the Fahey NO_y data, but there is an offset in the actual mass. We attribute

this offset to improper sample volumes on the MASP and are working to have the MASP PI recalibrate the instrument. We also produce the first mass/temperature data that clearly shows that these large particles are NAT. MASP also identified a particle mode near 1 μm radius not identified in any other data set. We are still trying to understand what these particles are made of. However, they clearly exist. Their mass is also possibly mis-estimated by MASP in the same way that the large particle mass is incorrect due to sample volume issues. Finally we have a paper on the spectroscopy of NAT particles, which is being resubmitted to JGR. This paper uses data from the DC-8 FTIR to show that the particles were made of NAT on at least one of the flights outside of the mountain wave region.. Finally we participated in writing the SOLVE overview paper (Newman et al., in press, 2002), and have submitted another paper (Hudson, P., et al., Uptake of nitric acid on ice at tropospheric temperatures: Implications for cirrus clouds) to J. Phys. Chemistry on the topic of nitric acid condensing on ice. We also published the papers with E. Jensen on PSCs, with A Tabazadeh on denitrification, and a summary paper of PSC properties in Science.

Published or submitted papers include::

1. "Arctic "Ozone Hole" in a cold volcanic stratosphere" (A. Tabazadeh, K. Drdla, M. R. Schoeberl, P. Hamill, and O. B. Toon, Pub. Nat. Acad. Of Science, 99, 2581-3356 (2002).
2. "An overview of the SOLVE-THESEO 2000 campaign" (Paul A. Newman, Neil R. P. Harris, Alberto Adriani, Georgios Amanatidis, Jim Anderson Geir Braathen, William Brune, Ken Carslaw, Michael Craig, Philip DeCola, Marielle Guirlet, Steve Hipskind, Michael Kurylo, Harry Küllmann, Niels Larsen, Gérard Mégie, Jean-Pierre Pommereau, Lamont Poole, Mark Schoeberl, Fred Stroh, Brian Toon, Chip Trepte, and Michel Van Roozendael), submitted to J. Geophys. Res. (2002).
3. "Uptake of nitric acid on ice at tropospheric temperatures: Implications for cirrus clouds" (P. K Hudson, J. E. Shilling, M. A. Tolbert, and Owen B. Toon), J. Phys. Chem., submitted (2002).
4. "Identification of nitric acid trihydrate (NAT) in the Arctic stratosphere using infrared extinction measurements"(D. L. Glandorf, W. G. Mankin, J. W. Hannigan, M. T. Coffey, S. T. Massie, B. Rajaram, E. V. Browell, O. B. Toon and M., A. Tolbert), J Geophys. Res, sub. (2002).
5. "Impact of polar stratospheric cloud particle composition, number density, and lifetime on denitrification" (E. J. Jensen, O. B. Toon, A. Tabazadeh and K. Drdla), submitted J. Geophys. Res., (2002).

6. "The role of polar freezing belt in stratospheric denitrification" (A. Tabazadeh, E. J. Jensen, O. B. Toon, K. Drdla, and M. R. Schoeberl), Science, 291, 2591 (2001).
7. "Solving the PSC Mystery" (Margaret A. Tolbert and Owen B. Toon), Science, 292, 61 (2001).